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Measurement Properties of a Self-Report Index of Ergonomic Exposures for Use in an Office Work Environment

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ABSTRACT

Office work-related upper extremity symptoms and disorders have been associated with static work posture, repetition, and inadequate recovery in the anatomic structures of the neck and upper extremities. Despite these associations there is relatively little research on the development of practical measures of these ergonomic exposures. The present study examines the measurement properties of an upper-extremity specific self-report index of ergonomic exposures. Ninety-two symptomatic office workers completed a web-based questionnaire measuring demographic variables, ergonomic exposures, pain, job stress, and functional limitations. Comparisons of internal consistency, construct validity, and discriminative and predictive abilities were made between the self-report index and an observational exposure assessment checklist. Results indicated that the self-report index had acceptable measurement properties. Furthermore, higher levels of self-reported ergonomic exposures were associated with upper extremity pain, symptom severity, and functional limitations. In contrast, higher levels of observed exposure were only related to lower levels of general physical function. The self-report measure has potential for use in occupational health surveillance programs for office work environments and as an outcome measure of ergonomic exposure in intervention trials. These results also suggest the need for utilizing multiple methods when assessing ergonomic exposures.

Key terms: self report, office ergonomic exposure, upper extremity symptoms, assessment, function, observational methods

INTRODUCTION

Despite a decreasing trend in overall numbers of workdays lost due to work-related injuries and illnesses [1] [2], the prevalence of work-related upper extremity disorders/symptoms (WRUEDs) has remained the same and these conditions continue to be a significant public health problem. A 1999 United States Department of Labor, Bureau of Labor Statistics (BLS) report [1] indicated that musculoskeletal disorders accounted for one out of every three injuries and/or illnesses that resulted in lost time, and more than 400,000 workers reported the loss of one or more workdays specifically due to WRUEDs. [1] Total healthcare and indemnity costs associated with severe cases can be considerable (e.g., $10,000 per reported case of carpal tunnel syndrome), [3] Furthermore, office workers account for approximately 5 % of all worker's compensation claims related to the upper extremities. [4]

WRUEDs are a diverse set of conditions characterized by pain, aching, stiffness, fatigue, discomfort, tingling, and/or numbness, generally in the fingers, hand, wrist, elbow, arm, shoulder, or neck. These symptoms can exist with or without loss of function. Epidemiological research suggests WRUEDs and associated disability are consequences of complex interactions among ergonomic, medical, and psychosocial factors. [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] Important medical factors include previous musculoskeletal conditions or trauma, surgical

treatments, or other concurrent medical conditions (e.g., pregnancy). Ergonomic factors related to WRUEDs include adverse environmental work conditions, static or extreme postures, excessive repetition, and inadequate rest and recovery. [5] [15] Key psychosocial factors that deserve particular consideration are perceived stress, poor employee-supervisor relationships, time/deadline pressures, high levels of perceived work demands, and perceptions of lack of job control or social support at work. [3] [7] [10] Many of these ergonomic and psychosocial factors can be found in modern office work environments and may contribute to development, exacerbation and maintenance of WRUEDs in office personnel. [3] [10]

Measurement of suspected ergonomic risk factors is complex. [11] [16] Ergonomic exposures have been measured using direct measurement (via instrumentation), observational (on-site or later with video recordings), and self-report (questionnaires) methods. [17] Although direct measurement is typically proposed as the "gold standard" for assessing ergonomic exposures, these techniques can be time consuming, relatively expensive, and their validity in relation to symptoms and functional limitations of musculoskeletal disorders requires further validation. [17] [18]

Occupational medical surveillance and control programs in the workplace require efficient methodologies with optimal measurement properties. Development of risk factor measurement tools that are practical, reliable,

inexpensive, efficient, and valid should facilitate office WRUEDs surveillance and control. Although self-report measures may overestimate exposures, [13] [14] [16] use of these measures may represent a practical and efficient method for evaluating potential work-related ergonomic exposures. [13] [18] [19] [20] [21] [22] [23] [24] However, few self-report measures that are specific to assessing upper extremity-related exposures have been examined in terms of their detailed measurement properties, [16] [17] [19] [21] [22] [25] and it is unclear how well self-report measures relate to observational workstation ergonomic assessment forms/checklists, [9] [19] [22] [26] often assumed to represent a more objective method. While observational assessments are a common field measurement method [17] (sometimes conducted in conjunction with direct physical measurements), few published studies could be found to document their validity. [27]

The present study was conducted on office workers who reported symptoms of WRUEDs to examine measurement properties of an upper extremity specific self-report index of ergonomic exposures and describe its association with an on-site observational workstation ergonomic exposure assessment form/checklist. Secondarily, this study evaluated whether the self-report index could discriminate and predict levels of pain, symptom severity, and functional limitations (after controlling for age, gender, and job stress). Comparison of

measurement properties of the self-report index and the observational exposure assessment checklist were also made.

METHODS

Subjects

Individuals employed at the World Bank Headquarters in Washington D.C., a global economic development organization, were recruited to participate in a randomized controlled trial (effects of ergonomic intervention vs ergonomic and job stress intervention) through two informational breakfast sessions and general organizational channels (i.e., flyers). Workers from departments that had a history of higher rates of past medical claims related to WRUEDs were invited to participate. To be eligible for the study, an individual must have met the following criteria: 1) symptoms (WRUEDs) experienced within the past 12 months that were not related to motor vehicle accidents, sports injuries, or any non-work-related trauma, 2) worked full-time in office environment (>32 hrs/week), 3) had not been pregnant within the past 12 months (includes absence of current pregnancy) and, 4) worked on computers for a minimum of >4hrs/day.

Of the 154 individuals who volunteered for the randomized controlled trial, 92 (65%) met the study inclusion criteria and participated fully. Full

participation by these 92 office workers included providing informed consent, participating in an ergonomic walk-through (i.e., observational assessment), and completing a web-based baseline questionnaire that measured demographics, job stress, ergonomic exposures, work demands, perception of work environment, pain intensity, and functional limitations. Data from the baseline questionnaire and observational ergonomic assessments were utilized for the present study.

Forty-four individuals were excluded as the result of an initial screening by questionnaire. The reasons for exclusion were report of symptoms that were related to previous trauma or accident ($\underline{n}$ = 27), pregnancy ($\underline{n}$ = 5), or use of a computer for less than 3 to 4 hr. per day ($\underline{n}$ = 2). Eighteen individuals were excluded at a later date when they did not complete the initial questionnaire for unknown reasons.

Measure of Self-Reported Ergonomic Exposures

The Job Requirements and Physical Demands Survey (JRPDS) was developed in 1996 by the Air Force (AF) for assessing ergonomic exposures in a variety of workplace settings. [28] While the initial validation study was not specific to office work environments, it indicated that JRPDS scores correlated with WRUEDs. [28] For each item in the index there are five possible categorical responses corresponding to an individual's perceived level of ergonomic exposure

(0 = never, 1 = < 5hr /wk, 2 = < 2 hr/day, 3 = 2-4 hr/day, 4 = > 4hr/day). For the purposes of this study, it was necessary to eliminate items not related to office work environments (e.g., questions relating to work using vibrating tools, etc.). Additionally, there was an interest in reducing the scale to provide a modified version of the JRPDS that measured upper extremity related exposures with the fewest number of items, but retained the characteristics of internal consistency and construct validity.

The categorical response distribution patterns of each item, along with two decision rules regarding item rejection, were used to reduce the original 36-item JRPDS down to a 24-item index. The decision rule used to eliminate any item from the questionnaire was as follows: 1) when a break in the distribution was noted, indicating that no subject responded in a specific category, and 2) when the item response frequency distribution across response categories indicated that more than one category level had only one individual response. Individuals completed the questionnaire selecting the response level that reflected, on average, the number of hours (daily or weekly) they performed each of the tasks presented. An individual's total JRPDS-24 Item Index score was obtained by summing the responses and could range from 0.0 to 96.0. The JRPDS-24 Item scale had a Cronbach's alpha of 0.816, which was approximate to the 0.845 value obtained for the original 36-item scale (from the current study). This finding

suggests that even by reducing the original full scale in a manner that assesses upper extremity specific exposures, there is no appreciable effect on the internal consistency.

Observational Workstation Assessment of Ergonomic Exposures

One of the study's goals was to investigate the relationship between the measurement properties of the self-report index and an observational assessment checklist. Since a true "gold standard" for quantifying office worker ergonomic exposures does not exist, this checklist was considered a proxy for a "gold standard".

The observational exposure checklist used in the present study to assess the criterion validity of the JRPDS-24 Index of self-reported ergonomic exposures was based on State of Washington Department of Labor and Industry's "Ergonomic Work-site Analysis Form". [29] This checklist was selected for study purposes because variations of such checklists are common field measurement tools used to assess suspected office ergonomic risk factors. Also this observational ergonomic exposure assessment checklist was designed for conducting on-site observed assessments of individual workstation exposures and generating recommendations for correction of any ergonomic exposures observed in an efficient manner. As such, it is a potentially useful tool for brief evaluation and onsite intervention. The checklist focuses on several different aspects of

workstations as they may be related to workstation ergonomic exposures (keyboard, mouse, monitor, other office equipment, paper documents, chairs, workspace, environment, and lifting and carrying). Checklist rater response options were "yes", "no", or "not applicable". All "no" responses were considered a potential ergonomic exposure (except for one item where yes = exposure). The total score for the observational exposure checklist was calculated based on the number of assumed exposures (total number of observed exposures divided by the total possible exposures) observed. The total scores could range from 0.0 to 9.0.

Measures of Pain, Symptoms, and Function

Various clinical scales were also used to measure a specific clinical outcome related to WRUEDs (i.e., symptom severity, general physical function, upper extremity functional limitations, pain). All have previously been validated and described. [9] [21] [30] [31] [32] [33]

A subset of items that measure symptoms (items #24 - #28) on the Disability Arm Shoulder Hand Outcome Measure [21][30] was used to assess severity of clinical symptoms. The Short Form 12 (SF-12) [9] [33] Health Survey is a population-based measure of health that is comprised of a general physical health and a mental health components summary scale. For this study, only the

general physical components summary (SF-12 PCS) scores were used as a measure of general physical function. The mental health components summary was not considered in the present study because of the study focus on pain and physical function outcomes. The Upper Extremity Function Scale (UEFS) is a clinical outcome measure used to assess the degree of upper extremity specific functional limitations. [31] [32] A visual analog scale of pain severity (VAS Pain) [9] was used to measure the degree of pain severity experienced during the last week.

Measure of Job Stress

The Job Stress subscale of the Life Stressors and Social Resources Inventory was completed by participants to determine levels of work-related conflicts, physical environment, and perceptions of work pace. [34] This scale was modified (omitted physical environment item). The modified Job Stress subscale was used as a control variable in regression analyses on clinical outcomes related to WRUEDs to control for the potential impact of occupational stress on clinical outcomes. It was reasoned that this would allow for a more precise evaluation of the independent contribution of the two ergonomic exposure assessment tools on clinical measures of pain, symptoms, functional limitations and general physical function.

Statistical Analyses

Statistical Software

All statistical data analyses were performed using Statistical Package for the Social Sciences (SPSS v10.0, 2001).

Univariate Data Exploration

Univariate analyses were performed. The distributions of all variables of interest were acceptably normal with the exception of the Upper Extremity Function Scale (UEFS) scores. The UEFS scores were converted to a log scale for subsequent regression analyses.

Reliability and Reproducibility

Since the dataset contained only baseline data, an evaluation of reproducibility (inter-rater/test-retest agreement) did not apply to the JRPDS-24 Index. The reliability (as measured by of degree of internal consistency) of both the JRPDS-24 Index and the on-site observational workstation ergonomic exposures assessment form/checklist were indicated by Cronbach's alpha. Since it is the intent of the self-report index in this study to focus on only one attribute (i.e., physical aspects of ergonomic exposure), an acceptable range of Cronbach's alpha was defined as 0.70 to 0.90. [35] Cronbach's alpha values in this range indicate homogeneity of the items in the index.

The reproducibility (inter-rater reliability) of the observational exposure checklist was assessed using discrete data that were available from a pilot study performed on a sample of the same work group (n = 427 observations, two independent ratings of 10 workstations). The kappa statistic was calculated to measure the degree of agreement between the two raters (beyond chance alone). Levels of agreement were defined as: kappa > 0.75 = excellent, kappa 0.40 to 0.75 = fair to good, kappa < 0.40 = poor. [16] The two raters simultaneously performed independent on-site observational assessments of each workstation. Both raters were trained to use the observational assessment checklist. One rater was an occupational health nurse with special training in ergonomics, the other an injury control researcher with specialized training and several years of experience in the areas of rehabilitation engineering, ergonomics, and injury prevention and control.

Construct Validity

The construct validity of the JRPDS-24 Index and the observational exposure checklist was determined through correlation analyses. The association of the total scores from each ergonomic exposures assessment tool with clinical measures of pain, symptom severity, upper extremity functional limitations, and general physical function were independently determined. Pearson's correlation coefficients were used to measure the strength of these associations/correlations.

The results were then used to compare the construct validities of the JRPDS-24 Index and the observational exposure assessments.

Criterion Validity

The criterion validity of the JRPDS-24 Item Index of ergonomic exposures was evaluated by performing correlation analyses with the total scores of the JRPDS-24 Index and the observational ergonomic exposures assessment scores.

Discriminatory and Predictive Validity

The discriminative capabilities of the JRPDS-24 Index and the observational exposure assessment checklist were each independently assessed to determine their abilities to differentiate levels of clinical measures for pain, symptom severity, upper extremity functional limitations, and general physical function. Individuals were divided into "high" and "low" groups based on their total scores on the JRPDS 24 Item Index and the total observational workstation ergonomic exposure assessment. The "high" group was defined as the highest quartile (individuals with total index scores $\geq 75^{th}$ percentile) and the low group was defined as the lowest quartile (individuals with total index scores $\leq 25^{th}$ percentile). The high and low group mean scores on the clinical measures of pain, symptom severity, upper extremity functional limitations, and general

physical health were compared using independent t-tests.

Multiple linear regression modeling was used to evaluate the predictive capabilities of the JRPDS-24 Index and the observational exposure assessments in relation to pain, symptom severity, upper extremity functional limitations, and general physical health. Age, gender, and job stress, were entered simultaneously into the hierarchical regression models as covariates. Observational exposure assessment and JRPDS-24 Index variables were subsequently entered hierarchically into the model.

RESULTS

Subject Characteristics

Study participants ranged in age from 25 to 61 years and had a mean age of 45.23 years (SD = 8.8). Participants worked an average of 43.4 hours/week (SD = 10.8), had an average of 12.7 years of service (SD = 8.0), and reported working with computers for 14.7 years (SD = 5.7). Eighty-three percent of the study subjects were female. Thirty subjects (30%) reported using some type of medication for their WRUED symptoms. Twenty-three out of those 30 subjects (76.7%) using medications reported using common over the counter (OTC) non-

steroidal anti-inflammatory drugs (NSAIDs), such as Aspirin or Motrin for their symptoms. Other specific subject characteristics are given in Table 1.

Instrument Measurement Properties

Distributions of Scores

The distribution (Figure 1) of JRPDS-24 Index total scores ($\underline{n}$ = 92) was normal (Kolmogov-Smirvov test, p = .20). While the scale could range from 0 to 96, actual total scores ranged from 5 to 62. The mean total score was 30.4 (SD = 13.29). The distribution of the observational workstation ergonomic exposure assessment total scores (Figure 2) also was normal ($\underline{n}$ = 89) (Kolmogov-Smirvov test, p = .20). Scores for this scale could range from 0 to a maximum possible score of 9.0. Actual observational exposure assessment total scores ranged from 0 to 3.95. The mean total score was 1.74 (SD = .88). Two individuals had not completed the baseline workstation assessment because of scheduling problems.

Reliability and Reproducibility

The observational exposures assessment checklist demonstrated good inter-rater agreement (kappa = 0.722, 95% Confidence Interval = 0.702 – 0.740, p < 0.001). [16] The JRPDS-24 Index demonstrated a high degree of internal

consistency [35] (Cronbach's alpha= 0.816). In contrast, the observational assessment checklist had a lower internal consistency (Cronbach's alpha = 0.483).

Construct Validity

The construct validity of both the JRPDS-24 Item Index and the observational exposure assessment checklist are listed in Table 2. The JRPDS-24 Item Index was significantly correlated ($p < 0.05$) with the clinical measures of pain, symptom severity, and upper extremity functional limitations (r ranged from 0.240 to 0.262), however, it did not significantly correlate with the general physical function measure ($r = 0.061$, $p > 0.05$). In contrast, the observational checklist was inversely correlated with the measure of general physical function ($r = -0.211$, $p < 0.05$), but was not significantly correlated ($p > 0.05$) with measures of pain, symptom severity, or upper extremity functional limitations (r ranged from – 0.077 to 0.099).

Criterion Validity

The JRPDS-24 Index was associated ($r = 0.328$, $R^2 = 0.1074$, $p < 0.01$) with observational workstation ergonomic exposure assessment scores (Figure 3).

Discriminative and Predictive Validity

The JRPDS-24 Index was able to discriminate levels of the clinical measures of pain, symptom severity, and upper extremity functional limitations, but not the general physical function measure (Table 3). The observational exposure assessment checklist did not discriminate levels of any of these clinical measures.

Results of the multiple linear regression analyses (Table 4) indicated that the JRPDS-24 independently accounted for 7 to 27 % of the variance for the various clinical outcomes. After controlling for age, gender, and job stress, the JRPDS-24 Index had statistically significant ($p < 0.05$) contributions to the models for pain, symptom severity, and functional limitations, but not for general physical function. The overall model for upper extremity functional limitations had significant predictive capability (model $p < .001$), and the JRPDS-24 Index accounted for 27% of the variance. The JRPDS-24 Index was not a predictor of other clinical outcome measures in these regression models. The observational workstation ergonomic exposure assessments did not demonstrate any predictive abilities in the multiple linear regression models (either with or without the JRPDS included in the model).

DISCUSSION

The main results of this study indicate that a self-report measure of ergonomic exposures had acceptable internal consistency, criterion validity, and greater construct validity when compared to an observational workstation assessment checklist. The JRPDS-24 Index of ergonomic exposures was able to differentiate levels of pain, symptom severity, and upper extremity functional limitations, but not general physical function. The measure also significantly contributed to a model of upper extremity functional limitations. In contrast, the observational exposure assessment was not able to discriminate levels or explain variance in the upper extremity specific clinical measures evaluated.

The JRPDS-24 Index demonstrated better construct validity when compared to the observational exposures assessment checklist. As expected, the upper extremity specific JRPDS-24 Index was found to be associated with pain, symptom severity, upper extremity function, and not the general physical function measure. In contrast, the observational workstation ergonomic assessments did not show any significant associations with pain, symptom severity or upper extremity function, and was correlated with lower levels of general physical function. These findings suggest that while the observational exposure assessment checklist may be measuring certain dimensions of ergonomic exposures that are associated with an individual's overall general physical

function, the self-report measure of exposure is consistently associated with clinical outcomes specifically related to upper extremity pain, symptom severity, and functional limitations.

The JRPDS-24 Index was judged to have criterion validity because it demonstrated associations with the observational measure of ergonomic exposures. This result suggests that while the two measures demonstrated some overlap, as with the results from the determination of construct validity, the two measures are probably assessing different aspects of exposure. This may in part be a function of the design of the measures. The JRPDS-24 Index was designed to measure perceived frequency and duration of ergonomic exposure using categorical response while the observational measure was designed for a rater to evaluate the presence or absence of exposures by direct observation of the worker and their workstation. Further study is warranted in regards to the measurement properties and validation of this observational exposure assessment measure using other approaches to assess exposure such as video analysis and measurement using instrumentation to quantify posture, repetition, force, and recovery .

The present results need to be considered in light of certain study limitations. The use of self-reported measures (selection, recall, misclassification), possible presence of a healthy worker effect, and the absence of asymptomatic controls limit conclusions that can be made from this work. Also, using a

secondary data set and accepting the practicality of a cross-sectional study design are limitations that need to be considered when making inferences from this study.

The JRPDS-24 Item Index has initially demonstrated adequate measurement properties and has potential for use in occupational health surveillance programs for office work environments. It may also be useful as an outcome measure of ergonomic exposure in intervention trials. The findings related to the observational measurement tool used in the present study, however, highlight the need for additional research and development of observational methods in office environments and illustrate the inter-method variance that have been reported in other studies. [17] [18] These results also suggest the importance of including both methods when assessing ergonomic exposures at least at the present time.

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FOOTNOTE

The JRPDS is in the public domain. A copy of the JRPD-24 version can be obtained from the authors.

Table 1 - Frequency of Subject Characteristics

Subject Characteristic	n (%)
Gender	
Male	16 (17.0)
Female	76 (83.0)
Education	
High school diploma/GED	3 (3.3)
Some college	12 (13.0)
AA / Bachelors	30 (32.6)
Some graduate work	6 (6.5)
Graduate degree	41 (44.6)
Job Type	
Professional	31 (33.7)
Analyst	13 (14.1)
Administration / Program Assistant	42 (45.7)
Specialist / Consultant	6 (6.5)
Average Distribution of Work [a]	
Desk	85 (18.0)
Computer monitor	90 (61.0)
Laptop	66 (4.0)
Meetings / seminars	91 (9.0)
Discussions with co-workers	89 (6.0)
Phone calls	89 (7.0)
Other	28 (3.0)

[a]Average Distribution of Work is listed as average % at the specific work area. Individuals may have responded under multiple work areas, therefore the frequency sum may be is > n = 92, and the percentage sum is > 100%.

Table 2 - Correlation of the JRPDS-24 Index and Observational Exposure Assessment Checklist with clinical scales

	Observational Exposure Assessment (*r*)	**JRPDS-24 Item Index (*r*)**
VAS Pain Scale	0.013	**0.260***
Borg Perceived Exertion Scale	0.099	0.175
DASH - Work Items Subscale	-0.077	0.028
DASH - Physical Function Subscale	0.000	0.161
DASH - Symptom Severity Subscale	-0.078	**0.240***
NIOSH Symptom Severity	0.003	0.088
UEFS - Upper Extremity Functional Limitations Scale	-0.180	**0.262***
SF-12 Physical Components Summary	**-0.211***	0.061

n = 92
r = Pearson's correlation coefficient
* $p < 0.05$

Table 3 - Clinical Outcomes for High and Low Ergonomic Exposure Groups

	High Exposure Group (n = 25)	Low Exposure Group (n = 25)	Mean Difference	95% CI for Mean Difference
JRPDS-24 Index				
Pain	6.12	4.39	**1.73****	0.60, 2.86
Symptom Severity	43.40	30.43	**12.97***	2.68, 23.24
Upper Extremity Functional Limitations	19.60	9.61	**9.95***	2.38, 17.52
General physical function	35.93	34.02	1.92	1.64, 5.47
Observational Exposure Assessment Checklist				
Pain	5.22	5.52	-0.30	- 1.57, 0.96
Symptom Severity	33.04	36.74	-3.70	- 13.70, 6.31
Upper Extremity Functional Limitations	15.34	17.13	-1.78	- 10.23, 6.66
General Physical function	31.96	35.01	-3.05	- 6.52, - 0.43

Note. High=75th percentile, Low=25th percentile.
* $p < .05$
** $p < .01$

Table 4 - Predictors of Pain, Symptom Severity, Upper Extremity Functional Limitations, and General Physical Function

Clinical Outcome	Predictor[a]	Model R^2	ΔR^2
Pain	Subject characteristics[b]	.007	.007
	Job stress	.010	.003
	OWEA[c]	.010	.000
	JRPDS-24	**.071**	**.061***
Symptom Severity	Subject characteristics[b]	.011	.011
	Job stress	.017	.006
	OWEA[c]	.021	.004
	JRPDS-24	**.085**	**.065***
Upper Extremity Functional Limitations	Subject characteristics[b]	.124**	.124**
	Job stress	.157**	.034
	OWEA[c]	.163**	.006
	JRPDS-24	**.276*** **	**.113** **
General Physical Function	Subject characteristics[b]	.136**	.136**
	Job stress	.188**	.052*
	OWEA[c]	.204**	.015
	JRPDS-24	**.220** **	**.016**

[a]Predictor when added to hierarchical model
[b]Subject characteristics are age and gender
[c]Observational Workstation Ergonomic Exposure Assessment
* p < .05
** p < .01
*** p < .001

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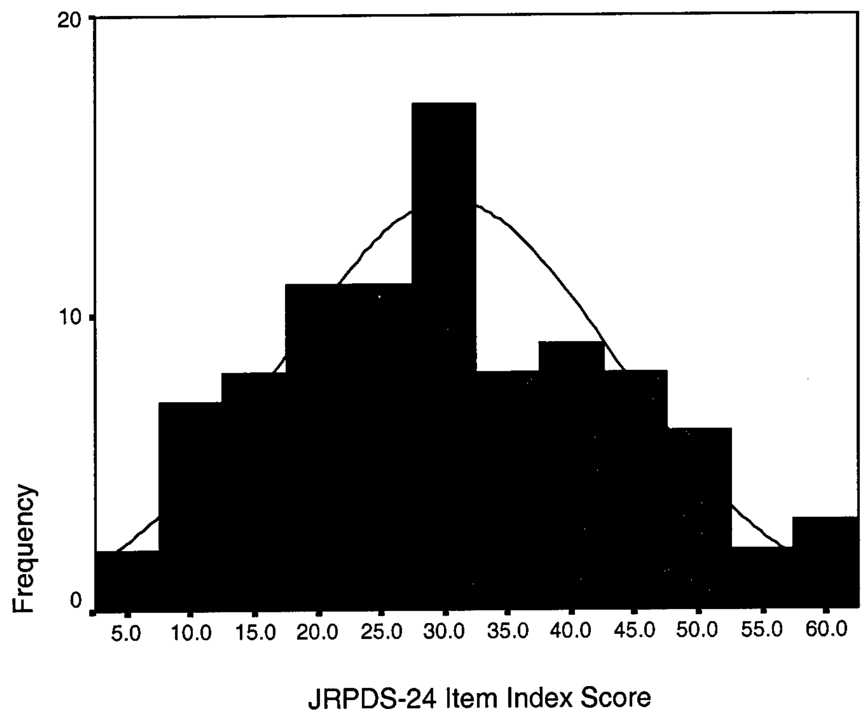

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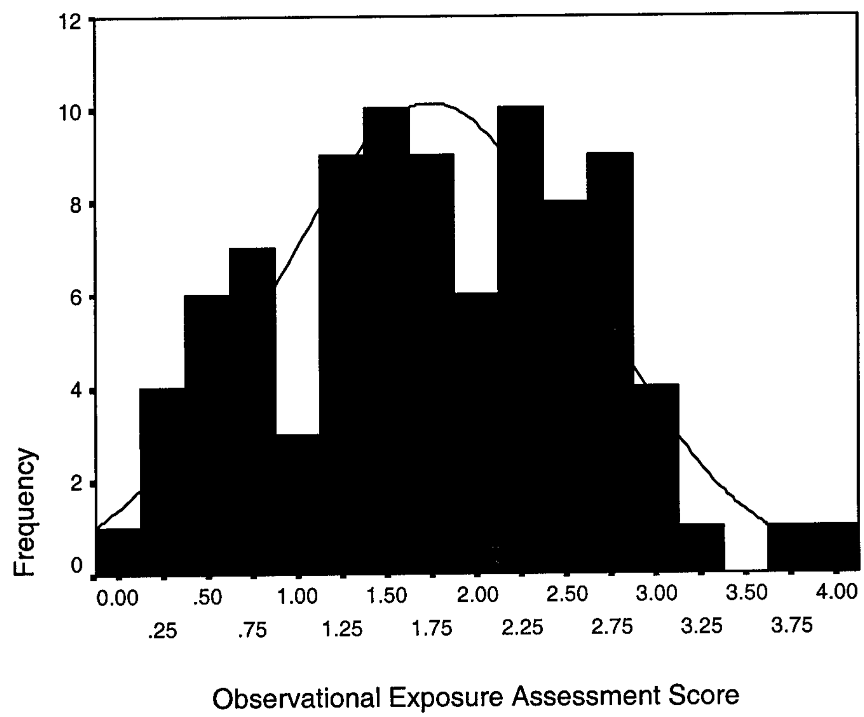

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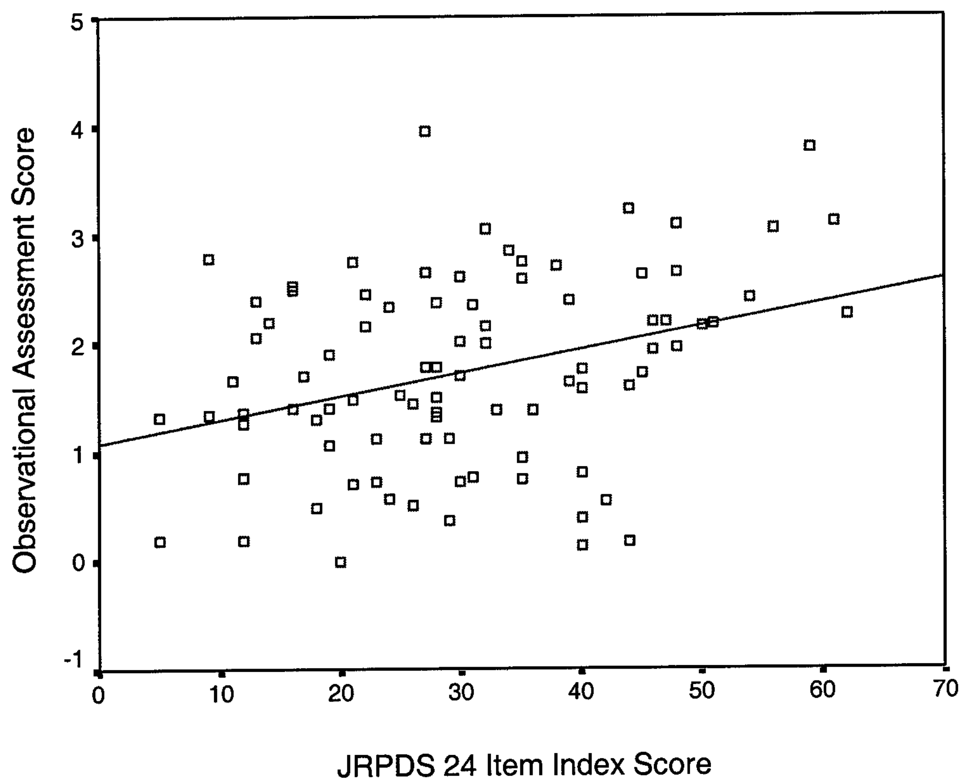
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JRPDS 24 Item Index Score

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